and 5 in. deep and is actuated by penetrating showers. Measurements of no field tracks indicate that the maximum detectable momentum for long tracks is well in excess of 10^{10} ev/c.

To date, 24 cases of V^0 decay have been observed in the new chamber, of which 12 have sufficiently long track lengths in the illuminated volume that the momentum determination is not likely to be in large error. The average momentum of these latter cases is rather high, so that relatively little direct information concerning the masses of the fragments is available. It is therefore necessary to analyze these events by a method which does not depend on assumption as to the character of the fragments.

Consider the decay in flight, as in Fig. 1, of a particle of mass M and velocity β into two fragments of masses m_+ and m_- and momentum p' in the c.m. system. Resolve p' into components p_x' and p_y' along the x' and y' axes, where x' corresponds to the direction of motion β. Since p_y' is invariant, it is equal to the so-called transverse component of momentum p_T observed in the laboratory frame of reference. Express p_x' in terms of the Manchester parameter α:

$$p_x' = \frac{(\alpha - \bar{\alpha})}{(2/\beta M)},$$

where

$$\alpha = (p_+^2 - p_-^2)/P^2, \quad \bar{\alpha} = (m_+^2 - m_-^2)/M^2.$$

Then, since $p_x'^2 + p_y'^2 = p'^2$, we have

$$\frac{(\alpha - \bar{\alpha})^2}{(2p'/\beta M)^2} + \frac{p_T^2}{p'^2} = 1.$$

For a given velocity β, this is the equation of a family of ellipses in the variables α and p_T. In the new results to be described below, the average value of β is very near unity, so that the results may for convenience be represented in the (α, p_T) plane for which $\beta = 1$, although it is clear that a three-dimensional representation is required, in general. The Q curves have a very simple physical significance in terms of the sphere S', on which lie the terminal points of $\mathbf{p}'$ in the c.m. system.

If a neutral particle is produced (three-body decay), then the observed points in the (α, p_T) plane scatter but all lie within the ellipse which corresponds to zero kinetic energy for the neutral particle in the true c.m. system.

The new data are plotted as rectangles in Fig. 2 and the data obtained with the 12-in. magnet[2] as circles. Solid points indicate a heavily ionizing positive fragment near protonic mass. A number of the points cluster on or near the curve $V_1^0 \rightarrow p + \pi$ $(\bar{\alpha} = 0.69)$ and give an average Q value of 37 Mev, in good agreement with the value 36 Mev previously reported by one of us[8] and with the best earlier value of 31 Mev.[2]

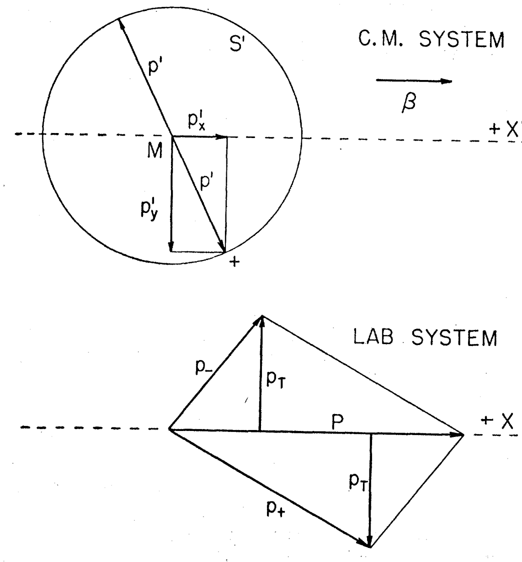

FIG. 1. Vector diagram of a V^0 disintegration.

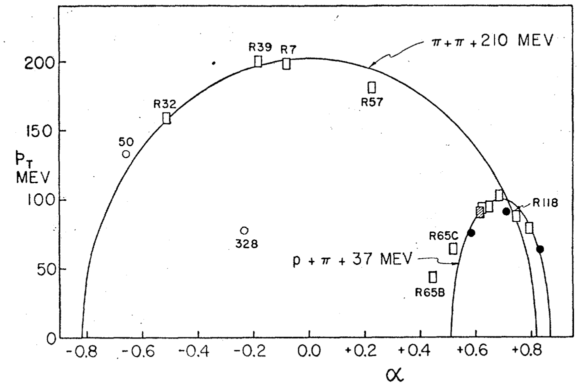

FIG. 2. Q curve plot of the V^0 disintegration data. In order to represent the decay of slowly moving V^0 particles in this diagram the values of α have been adjusted according to the decay scheme assignments in the text. Stereoscopic photographs of a three-dimensional model will be published in a forthcoming paper.

The remaining events[9] suggest the existence of a relatively large structure in the (α, p_T) plane with approximate height $p_T = 200$ Mev/c and center near the origin.

Events 50, R-32, R-39, R-7, R-57, and R-118 can be fitted with a single ellipse corresponding to the decay scheme $V^0 \rightarrow \pi + \pi + 210$ Mev[10,11] for which $M = 962\ m_e$,[12] in agreement with the published[2] value for event 50 of 1020 m_e or $Q = 240$ Mev for (π, π) decay.

However, if events 328[13] and R-65B represent the same disintegration process as the events just listed, a three-body decay may be indicated with a true Q value probably in excess of 210 Mev.

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† The essential conclusions of this note were reported at the Third Rochester Conference, the proceedings of which are in the process of publication by Interscience Press.

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8 Proceedings of the Second Rochester Conference, pp. 73–78, 1952.

9 Event R-118 is included since the positive fragment is apparently less massive than a proton. The negative fragment is heavily ionizing and is probably a pion or muon. This unusual event will be described in detail in a forthcoming publication.

10 A comparable fit is obtained with one or both fragments assumed to be muons.

11 We are indebted to Dr. Butler for recently informing us that the Manchester V_2^0 data have been re-analyzed to give a Q value in the neighborhood of 170 Mev instead of 122 Mev as previously reported.

12 It would be premature to more than note the similarity of this figure to the τ-mass.

13 Event 328 is an unpublished case of intermediate quality obtained with the 12-in. chamber. In R-65B both fragments traverse essentially the full height of the chamber with relatively high curvature, so that it is felt this point is probably distinct from the V_1^0 curve as drawn. However, the errors in R-65C are several times larger, and the event is not considered incompatible with the V_1^0 curve.

The Beta-Spectrum of Mg^{28}†

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THE beta-spectrum of Mg^{28} has been measured using the double magnetic lens spectrometer of Agnew and Anderson.[1] This isotope has been recently reported by Sheline[2] and also by

Lindner.[3] The Mg^{28} for this work has been prepared by spallation of Si and of K_2SO_4. Previous to the measurements in the beta-ray spectrometer, the isotope was studied and it was confirmed radiochemically that it is a Mg isotope and the activity of its daughter Al^{28} was separated and counted; so it was checked that the assignment as Mg^{28} was correct. The value of 20.8 ± 0.5 hr was determined for its half-life.

The samples for the beta-ray spectrometer were made by irradiating a few grams of the chemicals Si or K_2SO_4 in a copper vial at 420 Mev in the University of Chicago synchrocyclotron for about one hour. The targets with about 1 or 2 mg of Mg carrier were dissolved, hold-back carriers of likely active impurities added, and the Mg^{28} activity cleaned by precipitating impurities as sulfides in acid and basic solutions and by precipitating ferric hydroxide with ammonia. Finally, the magnesium was precipitated as the hydroxide with NaOH or was precipitated as the magnesium ammonium phosphate.

The samples for the beta-ray spectrometer were mounted in a thin Zapon backing; for that the magnesium was converted to the chloride or mounted directly as magnesium ammonium phosphate. The thinnest samples had thickness of about 0.2 mg/cm^2.

For the low energy part of the spectrum a Geiger counter with a window of Formvar E and a thickness of 0.2 mg/cm^2 was used. It was supported by a grid and filled *in situ* to 10 cm of Hg pressure with a mixture of 20 percent ethyl alcohol and 80 percent argon. For the high energy part of the spectrum a Geiger counter with a mica window of 1.3 mg/cm^2 was used.

A typical example of the results obtained is shown in Fig. 1. The high energy beta of Al^{28} shows an allowed shape from its end

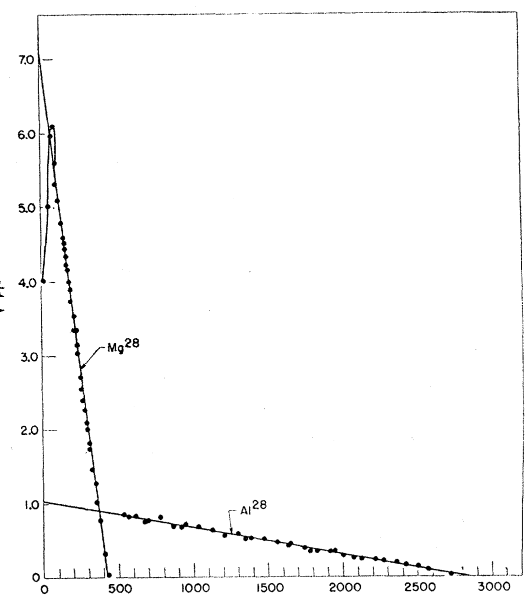

FIG. 1. The Fermi plot for the beta-spectra of Mg^{28} and Al^{28}.

point up to where the activity of Mg^{28} begins to appear. The extrapolated activity of Al^{28} for a given momentum was subtracted from the observed activity to obtain the activity of Mg^{28}. The Fermi plot of Mg^{28} obtained this way is shown also in Fig. 1, and it has an allowed shape for energies greater than 100 kev. Below 100 kev the usual experimental difficulties distort it. Most of the measurements gave similar results, and it can be concluded that both Mg^{28} and Al^{28} have allowed spectra. The most probable values for the maximum energies obtained are 418 ± 10 kev for Mg^{28} and 2850 ± 50 kev for Al^{28}. The value of logft for the decay of Mg^{28} comes out then to be 4.25. No other group of beta-activity could be detected, and it can be estimated that no less than 90 percent of the decay of Mg^{28} goes through the 418-kev beta.

I am indebted to H. L. Anderson for making available to me the beta-ray spectrometer and the facilities of the University of Chicago synchrocyclotron, and to R. K. Sheline for letting me know the results of his experiments before publication. Thanks are due L. Kornblith, Jr., C. Bordeaux, and the crew of the synchrocyclotron for their cooperation during the irradiations.

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Nuclear Magnetic Resonance Measurements of Selenium*

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(Received February 24, 1953)

MEASUREMENTS to determine the nuclear magnetic resonance of selenium 77 have been performed using a nuclear induction system. Frequencies were determined with a BC-221 frequency meter calibrated against standard frequency signals from WWV and an externally controlled crystal oscillator. The resonances occurred at a magnetic field of approximately 9500 gauss which was produced by an electronically regulated electromagnet.

The sample consisted of approximately 3 ml of H_2Se, and determinations were made relative to the resonance of deuterium in a 1-ml sample of D_2O containing 0.1 molar $MnSO_4$. The ratio of the resonance frequency of selenium to that of deuterium was determined to be

$$\nu(Se^{77})/\nu(D)=1.24211\pm0.00010.$$

The stated uncertainty is the estimated experimental error. The probable error as usually defined is ±0.000025 and the 95 percent confidence interval is ±0.000091.

This value for H_2Se is not in agreement with the value for H_2SeO_3 as determined by Dharmatti and Weaver,[1] and further investigations were carried out to ascertain whether or not the difference was real.

Using samples of H_2SeO_3 (aqueous), H_2SeO_4 (aqueous), and H_2Se, the following direct frequency ratios were found:

$$\nu(Se^{77}(H_2SeO_3))/\nu(Se^{77}(H_2Se))=1.001504\pm0.000040,$$
$$\nu(Se^{77}(H_2SeO_4))/\nu(Se^{77}(H_2Se))=1.001560\pm0.000080.$$

Since the resonance of H_2Se appears at the highest value of applied magnetic field, it appears to exhibit the least paramagnetic shielding. Measurements were also attempted on a sample of $SeOCl_3$, but conditions of the experiment were not suitable for satisfactory measurements.

Combining our measured ratios with Lindström's value for the deuteron to proton ratio[2] of 0.15350668, the selenium-to-proton frequency is calculated to be

$$\frac{\nu(Se^{77}(H_2SeO_3))}{\nu(H)}=\frac{\nu(H_2SeO_3)}{\nu(H_2Se)}\times\frac{\nu(H_2Se)}{\nu(D)}\times\frac{\nu(D)}{\nu(H)}=0.190959\pm0.000017.$$

Using the results of Dharmatti and Weaver[1] (0.72193) and Lindström's[2] sodium-to-proton frequency ratio of 0.2645182, we find their ratio to be

$$\frac{\nu(Se^{77}(H_2SeO_3))}{\nu(H)}=\frac{\nu(H_2SeO_3)}{\nu(Na)}\times\frac{\nu(Na)}{\nu(H)}=0.190964\pm0.000005.$$

It is concluded that our measurements are in substantial agreement with those of Dharmatti and Weaver and that a chemical